The Fish Fauna of Brackish Water Prawn Farming Ponds at Port Stephens, New South Wales

GREG B. MAGUIRE[1] **and J. D. BELL**[2,3]

[1]N.S.W. State Fisheries, Brackish Water Fish Culture Research Station, Salamander Bay, N.S.W. 2301. [2]N.S.W. State Fisheries, P.O. Box N211, Grosvenor Street, Sydney, N.S.W. 2000. [3]Present address: School of Biological Sciences, Macquarie Universiy, North Ryde, N.S.W. 2113.

ABSTRACT

A diverse fish fauna (49 species) was recorded in four tidal 0.11 ha prawn farming ponds which appear to act as fish traps. The potential deleterious effects of twelve of these species on prawn growth or survival are discussed in terms of the diet and reproductive biology of these fishes. Tarwhine *(Rhabdosargus sarba)* may be the most serious competitors with prawns for food while short- and long-finned eels *(Anguilla australis* and *A. reinhardtii)* are probably the greatest threat as predators especially as larger individuals appear to bypass the screens which act as filters during tidal water exchange.

INTRODUCTION

Two experimental prawn farming projects are being undertaken in ponds at Port Stephens, New South Wales. In the first project, juvenile school prawns (*Metapenaeus macleayi*) are collected from the Clarence River, N.S.W. and grown for up to three months to improve their market value (Maguire, 1976, 1980a, b; McBride and Maguire, 1979). In the second project, artificially reared postlarval prawns (*Penaeus plebejus, P. esculentus* or *Metapenaeus bennettae*) are grown for 6-9 months from mid-spring onwards (Maguire, 1976).

The presence of certain fishes within prawn farming ponds is undesirable because they prey upon prawns or compete for their food (Maguire, 1980a). Fish within the ponds can be killed by draining or poisoning ponds shortly before stocking with prawns but fish may continue to enter the ponds during the farming period. In the second of the above prawn farming projects, these fish may remain in the ponds long enough to grow to a size at which they could prey upon the prawns prior to harvest. This is unlikely to be a problem in the first project which involves shorter farming periods but the fish could still compete with the prawns for food.

The aims of the present study are to describe the composition of the fish fauna within the ponds and to relate this information to their feeding habits

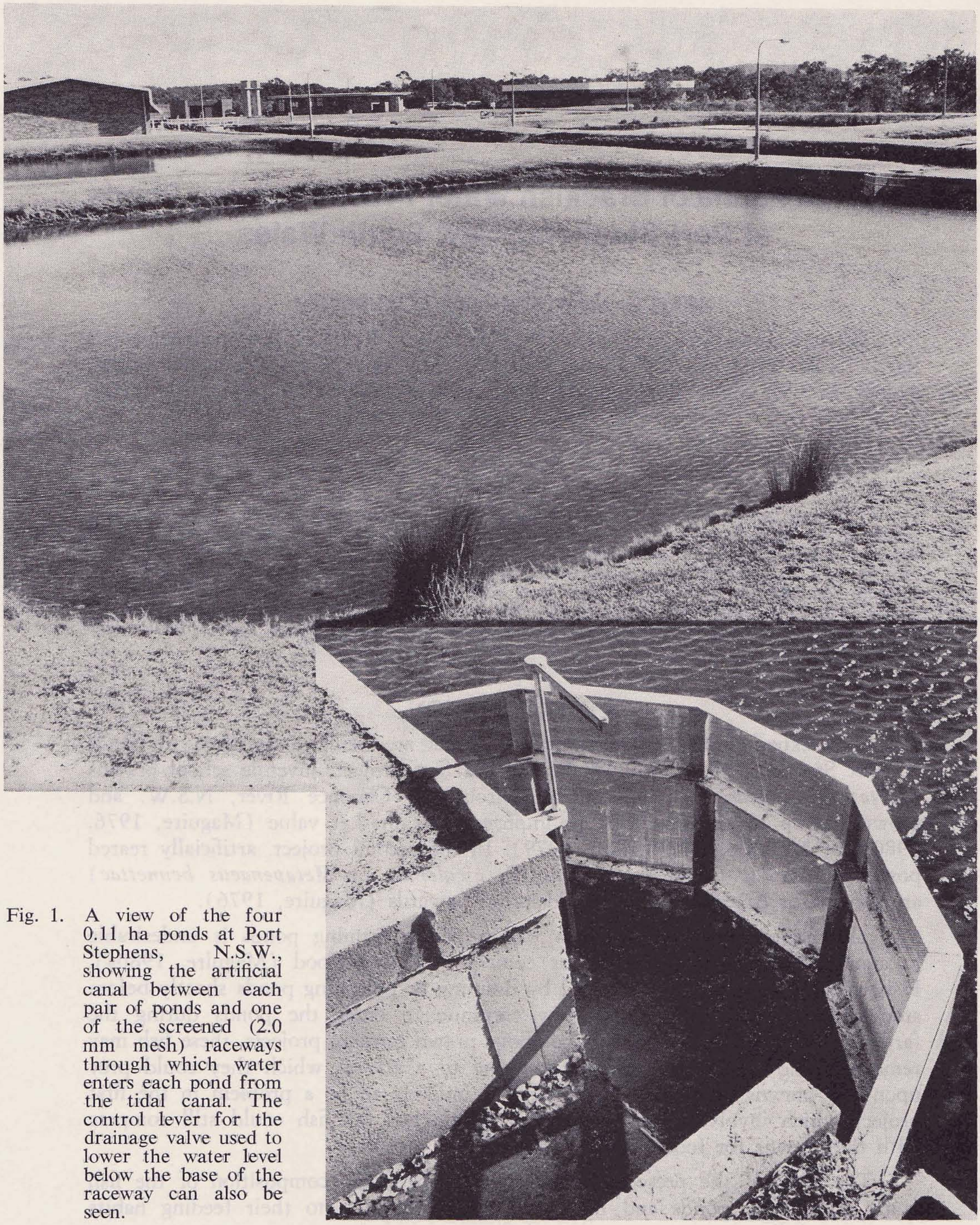

Fig. 1. A view of the four 0.11 ha ponds at Port Stephens, N.S.W., showing the artificial canal between each pair of ponds and one of the screened (2.0 mm mesh) raceways through which water enters each pond from the tidal canal. The control lever for the drainage valve used to lower the water level below the base of the raceway can also be seen.

and reproductive biology. This should enable fishes which are likely to seriously affect prawns stocked into the ponds, especially by preying upon them, to be identified. The present study complements that of Maguire and Bell (1981) in which competitive relationships between school prawns and some of the more common fishes in the ponds were investigated in experimental enclosures (pens) within the ponds.

MATERIALS AND METHODS

Description of Ponds

The four 0.11 ha prawn farming ponds used in this study are located at the Brackish Water Fish Culture Research Station, Port Stephens, N.S.W. (32°42'S, 152°12'E). These square ponds were excavated in an area of *Sporobolus virginicus* saltmarsh, the seaward fringe of which is occupied by *Avicennia marina* and *Aegicerus corniculatum* mangroves. The walls of some of the ponds and the adjacent tidal canal (Fig. 1) are being slowly colonised by these mangroves. The pond bottoms contain large amounts of wood and leaf detritus and fine-medium grade sand (125-500 μm grain size).

Water from an artificial canal connecting with the Port Stephens estuary enters each pond through a 2.0 mm mesh stainless steel screen after passing along a 0.9 m wide concrete raceway, the base of which is at a tidal level of 1.4 m above Indian Spring Low Water (Fig. 1). In each pond the average daily tidal water exchange (through 2.0 mm steel mesh screens) is approximately 70% of pond volume unless restricted during farming trials. Unless the drainage valve installed within the screened end of each raceway is opened, water is retained to at least raceway base level so that each pond contains approximately 1 m of water at low tide. The maximum water level recorded in the ponds is 2.3 m above Indian Spring low water; resulting in a maximum water depth of 1.9 m within the ponds.

Temperature and Salinity Measurements

Pond bottom water temperature and salinity measurements were taken daily in whichever pond received unrestricted tidal ventilation. Temperature recordings were made using thermographs or maximum-minimum thermometers. Salinity readings were taken with a Yeokal model 602, Hamon-type, salinity-temperature meter.

Fish Census

In January 1978 one pond was drained to a depth of 20 cm and poisoned by spraying with 2L of a rotenone solution (2.6% active ingredient) which killed all fish within the pond. Prior to the census the pond had not been stocked with prawns, netted or poisoned for 18 months and had usually received an

unrestricted rate of water exchange. An exhaustive collection of fishes was made with dipnets both within the pond and from the pond edge. The number of individuals of each species, their total weight and length range were then determined.

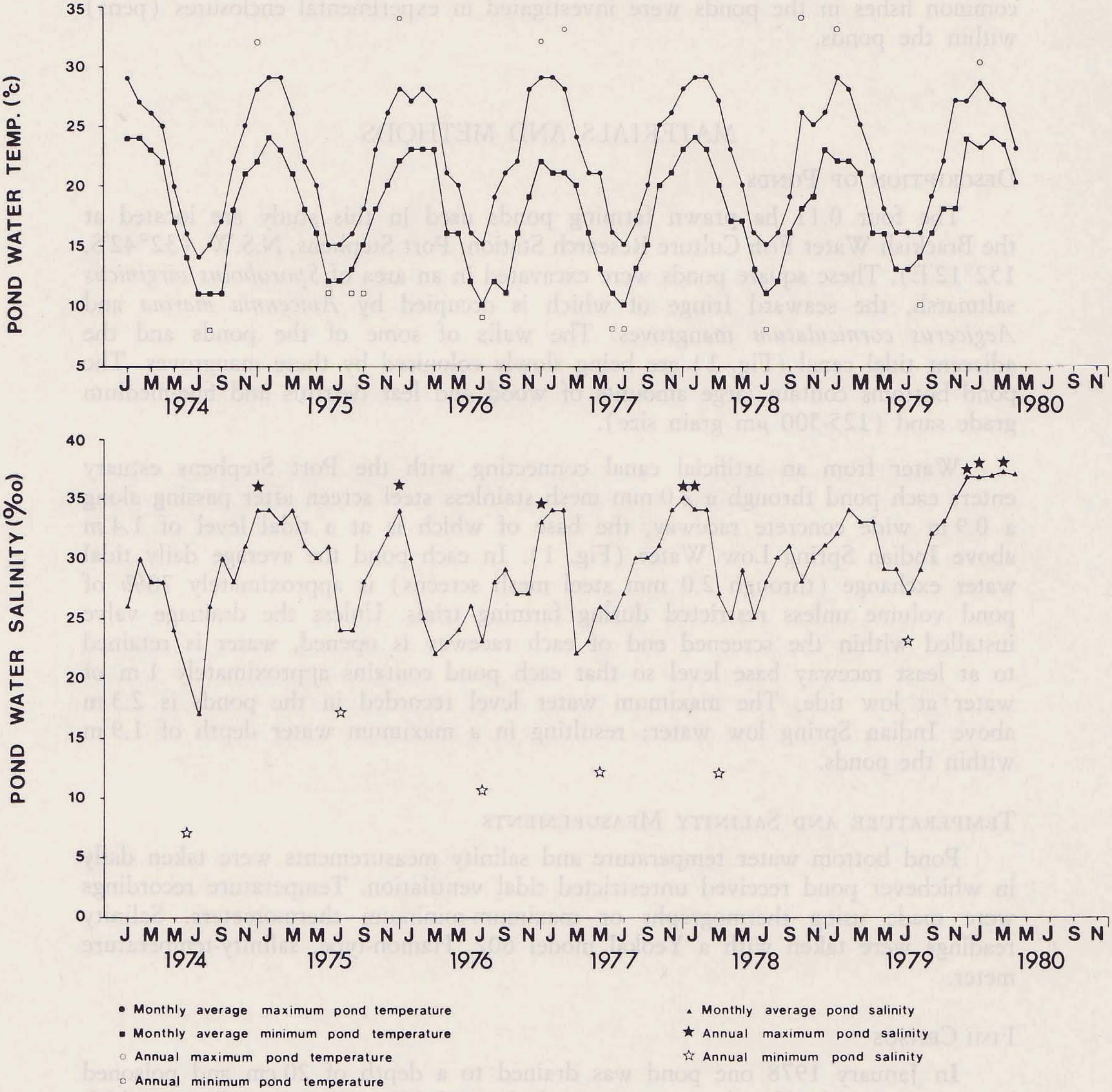

Fig. 2. Average monthly and annual extreme temperature and salinity values based on daily readings taken near the bottom of a 0.11 ha pond receiving unrestricted water exchange at Port Stephens, N.S.W.

RESULTS

Monthly averages of daily salinity and maximum and minimum pond water temperature readings in ponds receiving unrestricted water exchange during 1974-1980 are shown in Fig. 2. The extreme pond temperature and salinity ranges during this period were 8-34°C and 7-38‰ respectively.

TABLE 1. Fish species collected by poisoning a 0.11 ha prawn farming pond at Port Stephens, New South Wales.

Fish species	Common name	No. caught	Total wt. (g)	Length range (mm)
Anguillidae				
Anguilla australis	Short-finned eel	4	256.7	195-450[a]
Anguilla reinhardtii	Long-finned eel	5	500.0	120-500[a]
Anguilla spp	Juvenile eels	170	162.8	80-165[a]
Ophichthyidae				
Ophisurus serpens	Serpent eel	5	163.7	240-610[a]
Hemirhamphidae				
Hyporhamphus australis	Sea garfish	8	79.4	85-195[b]
Atherinidae				
Pseudomugil signifer	Southern blue-eye	10	1.0	15-30[b]
Atherinosoma microstoma	Hardyhead	1	0.3	35[b]
Scorpaenidae				
Centropogon australis	Fortescue	26	35.2	23-65[a]
Centropomidae				
Velambassis jacksoniensis	Glass perch	111	190.6	30-50[b]
Theraponidae				
Pelates sexlineatus	Six-lined trumpeter	11	151.3	85-110[b]
Sillaginidae				
Sillago ciliata	Sand whiting	2	4.5	60-65[b]
Gerridae				
Gerres ovatus	Silver-biddy	57	982.5	25-115[b]
Sparidae				
Rhabdosargus sarba	Tarwhine	526	1565.0	45-131[b]
Acanthopagrus australis	Yellowfin bream	152	1055.0	40-205[b]
Monodactylidae				
Monodactylus argenteus	Batfish	1	5.4	65[b]
Girellidae				
Girella cyanea	Bluefish	20	47.5	35-65[b]
Mugilidae				
Mugil cephalus	Sea mullet	2160	26115.0	65-250[b]
Myxus elongatus plus *Liza argentea*	Sand mullet Tiger mullet	360	720.0	30-60[b]
Blenniidae				
Omobranchus anolius	Sabre-toothed oyster blenny	4	5.8	50-64[a]
Omobranchus rotundiceps	Sabre-toothed oyster blenny	1	1.1	54[a]

TABLE 1 Continued

Fish species	Common name	No. caught	Total wt. (g)	Length range (mm)
Gobiidae				
Gobiopterus semivestita	Transparent goby	185[c]	1.4	14-19[a]
Pseudogobius olorum	Swan River goby	162	81.0	13-39[a]
Cryptocentroides cristatus	Crested goby	5	7.3	50-63[a]
Mugilogobius stigmaticus		12	12.2	31-55[a]
Mugilogobius paludis	—	4	1.2	28-34[a]
Favonigobius exquisitus	—	91	79.9	15-66[a]
Favonigobius lateralis	—	24	31.9	37-67[a]
Favonigobius tamarensis	Tamar River goby	23	11.3	15-53[a]
Acentrogobius sp.	—	55	147.1	23-72[a]
Arenigobius sp.	—	5	5.8	43-48[a]
Arenigobius frenatus	—	58	211.4	26-105[a]
Redigobius macrostomus	Largemouth goby	23	8.4	23-40[a]
Eleotridae				
Philypnodon grandiceps	Flathead gudgeon	7	9.9	47-61[a]
Gobiomorphus australis	Striped gudgeon	1	1.0	40[a]
Bothidae				
Pseudorhombus jenynsii	Small-toothed flounder	1	26.0	101[a]
Soleidae				
Achlyopa nigra	Black sole	3	103.3	100-175[a]
Monacanthidae				
Meuschenia trachylepis	Yellow-finned leather jacket	1	6.6	75[a]
Tetraodontidae				
Torquigener hamiltoni	Hamilton's toadfish	29	434.0	25-120[a]
	TOTAL (38 species)	4323	33222.6	13-610

a Total length (T.L.); b Length to caudal fork (L.C.F.); c A large number of very small (<0.01 g average body weight) transparent gobies remained uncounted in the pond.

TABLE 2. Additional fish species recorded from prawn farming ponds at Port Stephens, New South Wales.

Family	Fish species	Common name
Engraulidae	*Engraulis australis*	Anchovy
Hemirhamphidae	*Hyporhamphus ardelio*	River garfish
Belonidae	*Strongylura leiura*	Long-tom
Syngnathidae	*Hippocampus whitei*	Seahorse
Platycephalidae	*Platycephalus fuscus*	Dusky flathead
Girellidae	*Girella tricuspidata*	Blackfish
Callionymidae	*Callionymus calcaratus*	Stinkfish
Gobiidae	*Bathygobius krefftii*	Krefft's goby
	Nesogobius pulchellus	Pretty goby
Eleotridae	*Hypseleotris compressus*	Emperor gudgeon
Monacanthidae	*Monacanthus chinensis*	Fan-bellied leatherjacket
	TOTAL (11 species).	

The abundance and biomass of the 38 fish species belonging to 32 genera and 20 families) recorded during the census of a 0.11 ha pond are given in Table 1. Eleven species of fish (9 and 5 additional genera and families, respectively) not collected during the census but recorded at other times from the ponds are noted in Table 2. The most abundant fish caught during the census was sea mullet (*Mugil cephalus*) which accounted for 78.6% of the total fish biomass and 50.0% of the total number of individual fish collected. Other relatively abundant fishes included short- and long-finned eels (*Anguilla australis* and *A. reinhardtii*), glass perch (*Velambassis jacksoniensis*), silver-biddies (*Gerres ovatus*), tarwhine (*Rhabdosargus sarba*), yellowfin bream (*Acanthopagrus australis*), sand and tiger mullet (*Myxus elongatus* and *Liza argentea*) and several species of Gobiidae. These fishes were often abundant on other occasions when the ponds were harvested or poisoned prior to being stocked with prawns. Six species were considered to be potential predators of juvenile penaeid prawns within the ponds on the basis of studies of the stomach contents of fishes in N.S.W. estuaries (Table 3).

TABLE 3. Potential fish predators of prawns (> 2.5 g body weight) in prawn farming ponds at Port Stephens, New South Wales.

Fish species	Common name
Anguilla australis[ad]	Short-finned eel
Anguilla reinhardtii[ae]	Long-finned eel
Platycephalus fuscus[bcef]	Dusky flathead
Sillago ciliata[bdf]	Sand whiting
Acanthopagrus australis[acef]	Yellowfin bream
Pseudorhombus jenynsii[bc]	Small-toothed flounder

a Common in ponds.
b Only found in small numbers in ponds.
c Prawns found to be a major food item for this species (Thomson, 1959).
d Prawns found to be a minor food item for this species (Thomson, 1959).
e Prawns found in the stomachs of this species (Glaister, 1977).
f Prawns found in the stomachs of this species in Botany Bay, N.S.W. (Bell, 1980).

DISCUSSION

The water temperatures in these shallow ponds fluctuated more than those recorded by Wolf and Collins (1979) at the surface of the Port Stephens estuary near the artificial canal leading to the ponds. The annual minimum and maximum salinities were usually higher in the ponds than at Wolf and Collins' estuarine station. These large fluctuations in water temperature and salinity have not prevented the establishment of a large and diverse fish community in the prawn farming ponds. This can be seen in the comparison of the results of the census (Table 1) and those of the State Pollution Control Commission (S.P.C.C., 1981a).

They recorded a maximum of only 25 fish species and 2997 individual fish in any bimonthly sample taken over two years by poisoning a similar area of mangrove creek in Botany Bay, N.S.W.

Prawn farming ponds in other countries have also been found to contain diverse fish communities (Hall, 1962; Terazaki *et al.,* 1980). The composition of the diverse fish community in the Port Stephens ponds is probably related to the mesh size of the pond screens. All estuarine water and fish (except *Anguilla* spp.) entering or leaving the Port Stephens ponds have to pass through these screens which prevent fish longer than 10 mm (depending on shape) from entering or leaving the ponds. Thus many of the fish which entered the pond as eggs, postlarvae or small juveniles in the 18 months preceding this study would have been trapped in the ponds and recorded in the census. It is likely that the amount of tidal water exchange has a major effect on the number of individual fish inhabiting the ponds.

The ponds were not only characterised by their large fish community but also by the dominance within this community, in terms of biomass, of *Mugil cephalus*. Parker *et al.* (1972) also noted that this species was abundant in prawn farming ponds and Tang (1961), Silva *et al.* (1977) and Terazaki *et al.* (1980) suggested that various species of *Mugil* compete for food with prawns in ponds. However Maguire and Bell (1981) demonstrated that juvenile *Mugil cephalus* 55-155 mm (total length) had no apparent effect on the growth or survival rates of school prawns in pens within a pond even when stocked at high densities (1.5-7.6 fish/m^2). In contrast tarwhine and yellowfin bream were found to compete for food with, and depress the growth rates of, school prawns in pens. Furthermore they showed that relatively small yellowfin bream, e.g., 90 mm LCF, prey upon juvenile school prawns in pens. Both of these species of fish are common in the Port Stephens ponds. The studies by Munro (1945), Bell (1980) and S.P.C.C. (1981b) suggest that small postlarval tarwhine, e.g., 5-15 mm long, are present in New South Wales estuaries in spring, i.e. when postlarval prawns are stocked into ponds. Thus when tarwhine enter ponds they could grow to a size at which they would seriously compete for food with prawns. Yellowfin bream have generally been found to reproduce in winter in New South Wales and southern Queensland (Munro, 1945; Dredge, 1976; Bell, 1980; S.P.C.C., 1981b). Thus many postlarval yellowfin bream may be too large to enter through the screens after the ponds have been poisoned and stocked with postlarval prawns in mid-spring.

Maguire and Bell (1981) concluded that several of the remaining common species of fish in the ponds had little effect on school prawn growth and survival. Thus the presence of tiger mullet, silver-biddies and transparent gobies may not be harmful in prawn farming ponds. However, there are several other species which were abundant, or potential predators, within the ponds but which were not studied by Maguire and Bell (1981). Short- and long-finned eels have been

considered to be potential predators of juvenile prawns (Table 3). Although the elvers of these species may be present in estuaries in temperate Australian regions for most of the year (Beumer, 1979 and personal communication, 1981) they may be too large to pass through the screens. However, elvers have been observed climbing the high vertical surfaces of dam walls in coastal New South Wales rivers (Bishop and Bell, 1978). It is also likely that juvenile and larger eels could bypass the screens and climb directly over the sloping pond walls. Hence *Anguilla* spp. may pose a serious threat as predators within the ponds. Shigueno (1975) found that *Anguilla japonica* could bypass screens and prey upon prawns in Japanese farming ponds.

Dusky flathead (*Platycephalus fuscus*), sand whiting (*Sillago ciliata*) and small-toothed flounder (*Pseudorhombus jenynsii*) reproduce in summer in New South Wales (Bell, 1980; S.P.C.C., 1981b) and would enter the ponds too late in the growing season to grow to a size at which they could be serious predators by the time the ponds are harvested. One fish which was common in the ponds but not studied by Maguire and Bell (1981) because of its susceptibility to handling was the glass perch (*Velambassis jacksoniensis*). However, this species feeds on plankton (Thomson, 1959) and should have little effect on the benthic prawns farmed in the ponds.

In conclusion it is apparent that a wide variety of fishes enter and survive in tidally flushed prawn farming ponds. In longer prawn farming operations involving the stocking of postlarval prawns, the potential exists for fish to grow large enough to be serious predators as well as competitors for food with prawns. It should be noted that the prawns also grow during the farming period but this increase in size does not necessarily prevent predation. Shigueno (1975) found that predation by fish was the major cause of mortality in Japanese prawn farming ponds despite the eradication of fish within the ponds prior to the stocking of postlarval prawns. However, the stocking of postlarval prawns in mid-spring could reduce the deleterious effects of some of these fishes. Should certain species enter the ponds sufficiently early in the farming period to seriously reduce prawn harvests, additional management measures may have to be adopted, e.g., the use of eel barriers, filtering of incoming water through finer screens or periodic removal of fish from ponds. A low water exchange rate would restrict the opportunities for fish to enter ponds but could also adversely affect the physico-chemical characteristics of the ponds (Maguire, 1980a).

ACKNOWLEDGEMENTS

The authors wish to thank Dr. D. Pollard, J. Burchmore and P. Gibbs for commenting on the manuscript, D. Rodgers for providing photographic material and Dr. D. Hoese and H. Larson for identifying the gobies. Staff at the Brackish Water Fish Culture Research Station collected the pond temperature and salinity data. Their help and the assistance of the late W. Fox is gratefully acknowledged.

REFERENCES

BELL, J. D. (1980). Aspects of the ecology of 14 economically important fish species in Botany Bay, New South Wales, with special emphasis on habitat utilization and a discussion of the effects of man-induced habitat changes. Unpubl. M.Sc. Thesis, Macquarie University, 219pp.

BEUMER, J. P. (1979). Feeding and movement of *Anguilla australis* and *A. reinhardtii* in Macleods Morass, Victoria, Australia. *J. Fish. Biol.* **14:** 573-92.

BISHOP, K. A. and BELL, J. D. (1978). Observations on the fish fauna below Tallowa Dam (Shoalhaven River, New South Wales) during river flow stoppages. *Aust. J. Mar. Freshwater Res.* **29:** 543-9.

DREDGE, M. C. L. (1976). Aspects of the ecology of three estuarine dwelling fish in south-east Queensland. Unpubl. M.Sc. Thesis, University of Queensland, 122pp.

GLAISTER, J. P. (1977). Ecological studies on *Metapenaeus macleayi* (Haswell) (Crustacea, Decapoda, Penaeidae) in the Clarence River Region, northern N.S.W. Unpubl. M.Sc. Thesis, University of New England, 80pp.

HALL, D. N. F. (1962). Observations on the taxonomy and biology of some Indo-West-Pacific Penaeidae. *Fishery Publs. Colon. Off., No.* **17:** 229pp.

McBRIDE, R. L. and MAGUIRE, G. B. (1979). Taste panel evaluation of pond-fattened school prawns *Metapenaeus macleayi* (Haswell). *Aquaculture* **16:** 261-5.

MAGUIRE, G. B. (1976). Pond culture of prawns. *Fisherman,* **5**(2): 12-6.

MAGUIRE, G. B. (1980a). A review of the farming and biology of penaeid prawns with emphasis on juvenile school prawns *(Metapenaeus macleayi). N.S.W. State Fish. Tech. Rep.* 80pp.

MAGUIRE, G. B. (1980b). Farming of juvenile school prawns *(Metapenaeus macleayi)* in estuarine ponds. Unpubl. Ph.D. Thesis, University of New England, 299pp.

MAGUIRE, G. B. and BELL, J. D. (1981). The effects of fish on growth and survival of school prawns *Metapenaeus macleayi* (Haswell) in some Australian brackish water farming ponds. *Aquaculture* **24:** 267-83.

MUNRO, I. S. R. (1945). Postlarval stages of Australian fishes —I. *Mem. Qld. Mus.* **12:** 136-53.

PARKER, J. C., HOLCOMB, H. W. Jr., KLUSSMAN, W. G. and McNEILL, J. C. IV. (1972). Effect of fish removal on the growth and condition of white shrimp in brackish ponds. *Proc. Ann. Meet. World Mariculture Soc.* **3:** 287-97.

SHIGUENO, K. (1975). Shrimp Culture in Japan. (Association for International Technical Promotion: Tokyo).

SILVA, L. E. M., PEDINI, M. and NEW, M. B. (1977). Mullet *(Mugil incilis)* and freshwater prawn *(Macrobrachium acanthurus)* polyculture in Columbia. *Proc. Ann. Meet. World Mariculture Soc.* **8:** 195-206.

STATE POLLUTION CONTROL COMMISSION, S.P.C.C. (1981a). The ecology of fish in Botany Bay — community structure. *S.P.C.C. Tech. Rep.* **BBS23A:** 127pp.

STATE POLLUTION CONTROL COMMISSION, S.P.C.C. (1981b). The ecology of fish in Botany Bay — biology of commercially and recreationally valuable species. *S.P.C.C. Tech. Rep.* **BBS23B:** 287pp.

TANG, Y. (1961). The use of saponin to control predaceous fishes in shrimp ponds. *Prog. Fish-Cult.* **23:** 43-5.

TERAZAKI, M., THARNBUPPA, P. and NAKAYAMA, Y. (1980). Eradication of predatory fishes in shrimp farms by utilization of Thai tea seed. *Aquaculture* **19:** 235-42.

THOMSON, J. M. (1959). Some aspects of the ecology of Lake Macquarie, N.S.W. with regard to an alleged depletion of fish. IX. The fishes and their food. *Aust. J. Mar. Freshwater Res.* **10:** 365-74.

WOLF, P. H. and COLLINS, A. J. (1979). Summary of daily temperature and salinity records for major oyster-bearing estuaries of New South Wales. *N.S.W. State Fish. Tech. Rep.* 107pp.